CSDL Informal Technical Note No. 10

DESCRIPTION OF THE RIVER CLIMATOLOGY DEVELOPED FOR NOS ROMS-BASED OPERATIONAL OCEANOGRAPHIC FORECAST SYSTEMS FOR CHESAPEAKE, DELAWARE, AND TAMPA BAYS

Silver Spring, Maryland
July 2011

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Coast Survey Development Laboratory

Office of Coast Survey
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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July 2011

noaa National Oceanic and Atmospheric Administration

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LIST OF ACRONYMS

CBOFS – Chesapeake Bay Operational Forecast System
CSDL – Coast Survey Development Lab
CO-OPS – Center for Operational Products and Services
DBOFS – Delaware Bay Operational Forecast System
ft^3/s – Cubic Feet per Second
m^3/s – Cubic Meters per Second
MMAP – Marine Modeling and Analysis Programs
MSL – Mean Sea Level
NAD27 – North American Datum of 1927
NGVD29 – National Geodetic Vertical Datum of 1929
NOS – National Ocean Service
NWIS – National Water Information System
NWS – National Weather Service
OCS – Office of Coast Survey
OFS – Operational Forecast System
ROMS – Regional Ocean Modeling System
SHEF – Standard Hydro-meteorological Exchange Format
SST – Sea Surface Temperature
TBOFS – Tampa Bay Operational Forecast System
USGS – United States Geological Survey

EXECUTIVE SUMMARY

The National Ocean Service (NOS) Marine Modeling and Analysis Programs (MMAP) branch of the Coast Survey Development Laboratory in cooperation with the NOS' Center for Operational Oceanographic Products and Services (CO-OPS) and Rutgers University has developed two new estuarine operational oceanographic nowcast/forecast modeling systems (OFSs) for Delaware Bay and Tampa Bay and upgraded the present forecast system for Chesapeake Bay to use Rutgers University's Regional Ocean Modeling System (ROMS) as the core model. These ROMS-based OFSs will require near real-time observations of river discharge, water temperature, and possibly salinity for their hourly nowcast cycles. However, such observational river data may not be available for all required geographic locations and available all the time. In addition, the observations may be erroneous due to sensor or transmission problems at a particular river observing gauge. Therefore, a river climatology was needed to provide a secondary or backup source of river information for the OFSs when observations are not available or found to be erroneous and also to form the basis of a quality control system to identify erroneous observations. The river climatologies are used by NOS High Performance Computing Coastal Ocean Modeling Framework (HPC-COMF) which performs data preparation, submits the ocean model for execution, and archives model output for an OFS' nowcast and forecast cycles (Zhang et al. 2010).

Five types of river discharge and water temperature climatologies were created at U.S. Geological Survey (USGS) river gauge locations needed by the three ROMS-based OFSs. These included 1) daily mean river discharge climatology, 2) daily mean water temperature climatology, 3) daily mean salinity climatology (for CBOFS only), 4) mean annual and extrema river discharge climatology, and 5) mean annual and extrema water temperature climatology. The climatologies were created using historical discharge, water temperature, and salinity data from USGS gauges. The amount of historical data used in creating these river climatologies ranged from 2 to 101 years, depending on the length of the data record at a gauge.

However, when the three ROMS-based OFSs became operational at CO-OPS in September and October 2010, only the 1) daily mean river discharge and water climatologies and 2) mean annual and extrema river discharge climatology are actually be used by the HPC-COMF data preparation software. The mean annual and extrema water temperature climatology is presently not used by these three OFSs, but may be utilized in future versions.

The daily mean river discharge and water climatologies are used as a backup by HPC-COMF if no real-time observations are available at any USGS station. These daily climatologies are contained in a single netCDF file named *nos.ofs.river.clim.usgs.nc*. (The file also contains daily mean salinity at CBOFS' USGS gauges but this information is not presently used by CBOFS.)

The mean annual and extrema river discharge are used by HPC-COMF data preparation software to QC the real-time river discharge observations. This climatology is contained in Section 1 of the individual river control text files for each OFS, *nos.cbofs.river.ctl*, *nos.dbofs.river.ctl*, and *nos.tbofs.river.ctl*.

1. INTRODUCTION

The National Ocean Service's (NOS) Marine Modeling and Analysis Programs (MMAP) branch of the Coast Survey Development Laboratory (CSDL) in cooperation with the NOS' Center for Operational Oceanographic Products and Services (CO-OPS) and Rutgers University has developed two new estuarine oceanographic nowcast/forecast modeling systems for Delaware Bay and Tampa Bay which use the Rutgers University's Regional Ocean Modeling System (ROMS) (Haidvogel et al. 2008) as the core numerical ocean circulation model. In addition, MMAP is replacing the present NOS forecast modeling system for Chesapeake Bay with one that uses ROMS. These three OFSs became operational in September and October 2010.

ROMS is a finite difference hydrodynamic model using a quasi-orthogonal curvilinear grid system with a terrain-following sigma grid in the vertical. ROMS can accept the following surface or boundary forcing inputs such as 1) tides, 2) river conditions, 3) surface atmospheric conditions, 4) open ocean boundary conditions, and 5) sea surface temperature (Urizar and Lanerolle 2010). In terms of river forcing, ROMS requires the following information: 1) a time vector associated with the river data, 2) river volume discharge, 3) water temperature, 4) salinity, 5) river location on ROMS grid, 6) river direction, and 7) the vertical profile/shape of the river. Information on where river discharge data are specified on the each of the three OFSs is contained in the ROM river control text files. These control files are shown in Appendix A.

Since the purpose of the NOS prediction systems is to provide hourly nowcasts and short-term forecast guidance of oceanographic parameters of water currents, salinity, water temperature, and water levels, the new ROMS-based OFSs require near real-time observations of river discharge, water temperature, and salinity for their nowcast cycles. The importance of near real-time river information for NOS forecast modeling systems has been described by Thomson (2000) and Westington and Kelley (2003).

However, near-real-time river observational data may not be available for all required geographic locations and available all the time. In addition, the observations at a particular gauge may sometimes be erroneous due to sensor or transmission problems. Therefore, the NOS OFSs need to use alternative types of data when observations are not available or the data falls outside of expected ranges in order to ensure the successful operation of the forecast systems.

This technical memorandum describes the river climatologies which were developed for the new ROMS-based OFSs for Chesapeake, Delaware, and Tampa Bays by Jay Benedetti, former ERT Intern in MMAP and updated by Yi Chen, present ERT intern. The memorandum includes descriptions of the five river climatologies: 1) daily mean river discharge climatology, 2) daily mean water temperature climatology, 3) daily mean salinity climatology (only for CBOFS), 4) mean annual and extrema river discharge climatology, and 5) mean annual and extrema water temperature climatology.

2. DAILY MEAN RIVER DISCHARGE, TEMPERATURE, AND SALINITY CLIMATOLOGIES

2.1. Description

Daily mean river discharge and water temperature climatologies were developed for USGS river gauge whose observations are used by the three new ROMS-based OFSs. In addition, daily mean river salinity climatologies were created only for gauges used by CBOFS. The purpose of the climatologies is to provide an estimate of discharge, water temperature and salinity (at only CBOFS' USGS gauges) when near-real-time observations are not available (e.g. malfunctioning gauge, not reporting) in order to ensure the successful completion of an OFS.

The daily river discharge, water temperature and salinity climatologies include values for every day of the year (Figure 1). The climatologies were obtained directly from the USGS National Water Information System (NWIS) website (http://waterdata.usgs.gov/nwis/nwisman/). However, the daily river discharge was converted to cubic meters per second using the conversion: *1 ft^3/s = .0283 m^3/s*. River discharge, temperature and salinity climatological data were often not available for the leap year day, February 29th. In order to compensate, an average was taken using data from February 28th and March 1st to compute the value.

When river water temperature climatology was not available for a particular USGS gauge from NWIS, the nearest gauge's water temperature climatology was used as a replacement.

The salinity climatology was only created for the 9 USGS gauges in the CBOFS domain. Thus, a missing value flag -999 was used to indicate that salinity climatology was not created at the USGS gauges used by the DBOFS and TBOFS.

Month	Day	Discharge (m^3/s)	Mean Temp. (ºC)	Salinity (psu)
1	1	-0.3	19.3	0.21
1	2	2.7	19	0.18
1	3	0.1	18.7	0.29
1	4	-2.6	18.6	0.3
1	5	-0.3	18.8	0.24
Continues until the end of the month				
2	1	-8.2	19.3	0.21
2	2	7.4	19.6	0.20
2	3	9.4	19.8	0.19
2	4	6.8	19.6	0.19
2	5	1.8	18.7	0.20

Figure 1. Sample content of daily mean river discharge, water temperature and salinity climatology for a station.

The daily river discharge, water temperature and salinity climatologies for all gauges for the three OFSs were incorporated by CO-OPS into a single netCDF file named *nos.ofs.river.clim.usgs.nc*. As of October 2010, the file contains climatologies for 57 USGS river gauge stations.

Whether the daily mean discharge climatology for a particular gauge is used by a OFS depends on the "Q_Flag" found in section 1 of the OFS river control file. The value 1 indicates that real-time river discharge observations will be used whereas a 0 indicates that mean daily discharge climatology be used instead. A similar flag, "TS_Flag" is employed to instruct the OFS whether to use daily mean water temperature climatology (value=0) or real-time observations (value=1).

2.2. TBOFS

Daily mean river discharge and water temperature climatologies were created for 17 river gauge locations necessary for TBOFS (Figure 2). The river gauges selected for TBOFS were determined by Wei (2009) of NOS/Coast Survey Development Laboratory (CSDL). Geographic information on the 17 gauges along with information on the length of the observation record used to create the climatology at the gauge is given in Table 1.

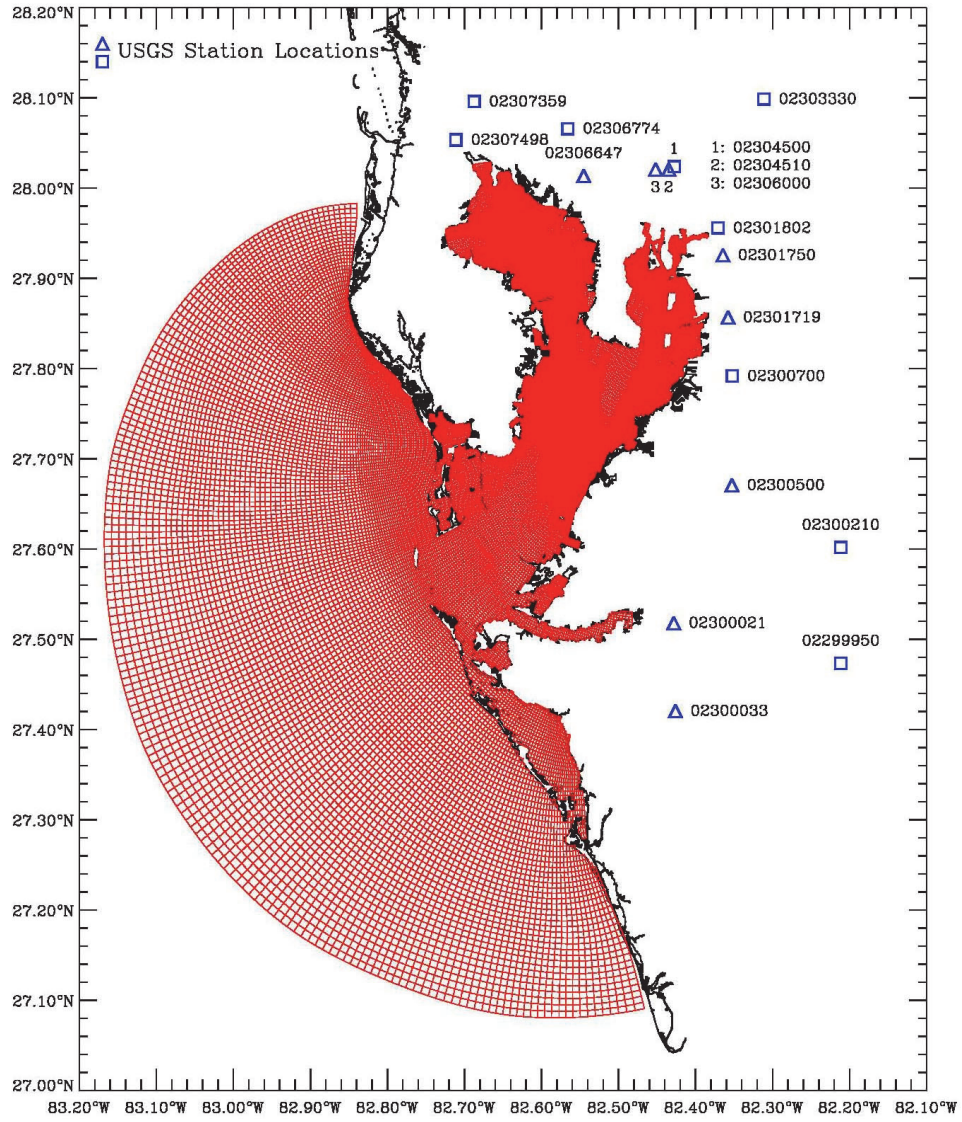

Figure 2. Map depicting the ROMS grid used for TBOFS along with locations of the 17 USGS river stations where discharge and/or water temperature climatologies were created/referred for TBOFS. Nine stations (squares) were used for hindcast runs. Eight stations (triangles) are used in the four times/day operational nowcast/forecast cycles.

Table 1. Information on 17 USGS River Gauges at which mean daily river discharge and/or water temperature climatologies were created for TBOFS.

USGS Station ID	NWS SHEF ID [1]	Gauge Station Name	State/ Prv.	Latitude (degrees) [2]	Longitude (degrees) [2]	Elevation (above MSL) [3]		Start Year	End Year	No. of Years
						Feet	Meter			
02299950	MKHF1	Manatee River near Myakka	FL	27.4733	82.2114	40.93	12.48	1966	2009	43
02300021 *	99999	Manatee River at Fort Hamer	FL	27.5181	82.4283	0.00	0.00	2006	2009	3
02300033 *	99999	Braden River at Lakewood Ranch	FL	27.4206	82.4261	-3.79	-1.16	2005	2009	4
02300210	99999	South Fork Little Manatee River	FL	27.6017	82.2114	53.84	16.41	2000	2009	9
02300500 *	99999	Little Manatee River near Wimauma	FL	27.6708	82.3528	0.00	0.00	1939	2009	70
02301719 *	99999	Alafia River near Gibsonton	FL	27.8567	82.3578	0.00	0.00	1999	2009	10
02303330	MORF1	Hillsborough River at Morris Bridge	FL	28.0986	82.3114	0.00	0.00	1972	2009	37
02304500	99999	Hillsborough River near Tampa	FL	28.0236	82.4278	0.00	0.00	1938	2009	71
02304510 *	99999	Hillsborough River at Rowlett Park Dr.	FL	28.0208	82.4347	0.00	0.00	2003	2009	6
02306000 *	99999	Sulpher Springs at Sulpher Springs	FL	28.0208	82.4519	0.00	0.00	1959	2009	50
02306647 *	99999	Sweetwater Creek near Tampa	FL	28.0136	82.5453	0.00	0.00	1985	2009	24
02306774	99999	Rocky Creek near Citrus Park	FL	28.0658	82.5658	0.00	0.00	1985	2009	24
02307359	99999	Brooker Creek near Tarpon Springs	FL	28.0958	82.6875	0.00	0.00	1950	2009	59
02307498	99999	Lake Tarpon Canal near Oldsmar	FL	28.0533	82.7111	-10.00	-3.05	1974	2009	35
02300700	99999	Bullfrog Creek near Wimauma	FL	27.7917	82.3522	0.00	0.00	1956	2009	53
02301802	99999	Tampa Bypass Canal at S-160	FL	27.9558	82.3708	0.00	0.00	1974	1990	16
02301750 *	99999	Delaney Creek near Tampa	FL	27.9256	82.3644	10.72	3.27	1984	2009	25

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF ID for that USGS gauge
[2] Referenced to horizontal control datum NAD27
[3] Referenced to vertical geodetic datum NGVD29
* Denotes stations used in the operational nowcast/forecast cycles

Each USGS river gauge has its own discharge/water temperature climatology text file with the naming convention *USGS_StationID_Dailymean_Dsch-Temp.dat* where StationID is the USGS Station ID.

The daily mean river discharge and water temperature climatologies for each USGS station along with the daily climatologies for stations used by other two OFSs are included in a single netCDF file called *nos.ofs.river.climo.usgs.nc*. This is the file used for the operational nowcast/forecast cycles of the three OFSs.

2.3. DBOFS

Daily mean river discharge and water temperature climatologies were created for 11 river gauge locations necessary for DBOFS (Figure 3). The river gauges selected for DBOFS were provided Schmalz (2009) of NOS/CSDL. The daily water temperature climatology for the USGS Delaware River at Trenton, NJ Gauge (USGS Station ID 01463500) was calculated by averaging two NWIS daily water temperature climatologies, one valid for the Pennsylvania side of the river and other on the Delaware side. Geographic information on the 11 gauges along with information on the length of the observation record used to create the climatology is given in Table 2.

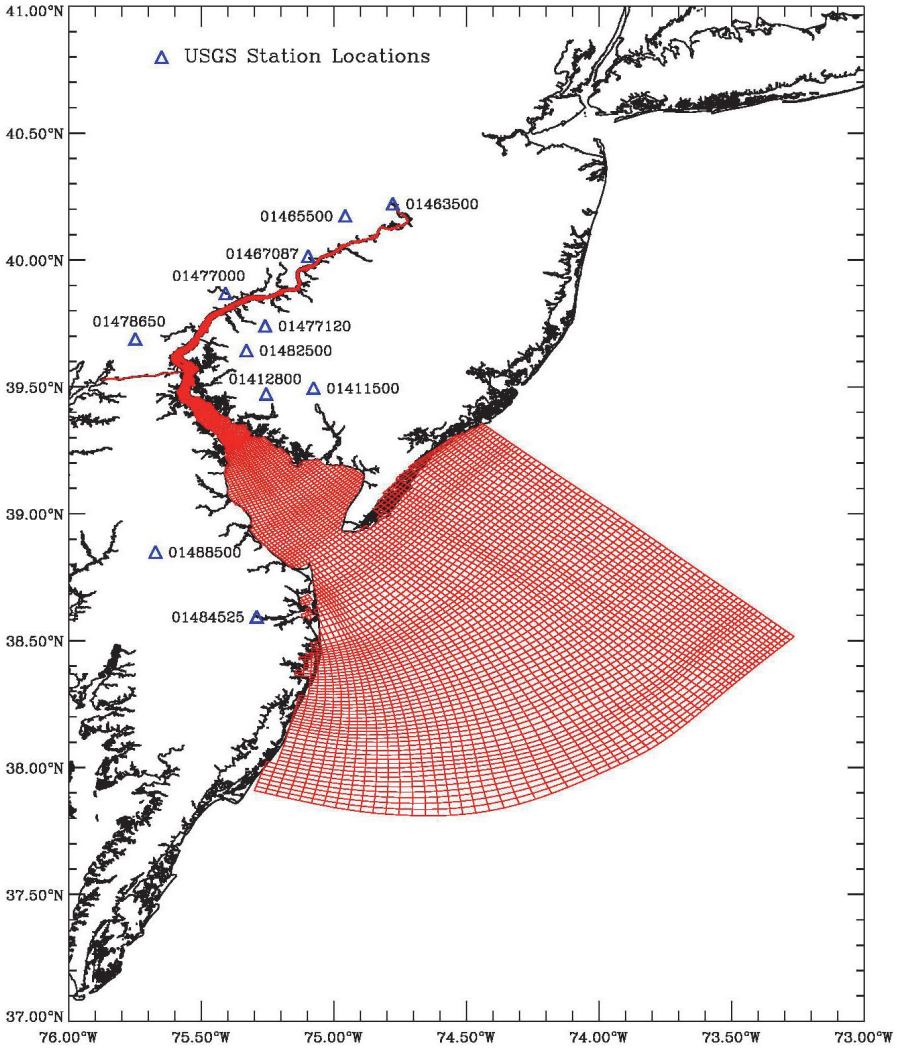

Figure 3. Map depicting the ROMS grid used for DBOFS along with locations of the 11 USGS river stations where discharge and/or water temperature climatologies were created/referred for DBOFS. The 11 climatologies were used for hindcast runs and are used in the four times/day operational nowcast/forecast cycles.

Table 2. Information on the 11 USGS River Gauges at which mean daily river discharge and/or water temperature climatologies were created for DBOFS.

USGS Station ID	NWS SHEF ID[1]	Gauge Station Name	State/ Prv.	Latitude[2] (degrees)	Longitude[2] (degrees)	Elevation (above MSL)[3]		Start Year	End Year	No. of Years
						Feet	Meters			
01412800	99999	Cohansey River at Seeley	NJ	39.4725	75.2556	26.90	8.20	1977	2009	32
01477120	99999	Raccoon Creek near Swedesboro	NJ	39.7406	75.2592	0.00	0.00	1966	2009	43
01482500	99999	Salem River at Woodstown	NJ	39.6439	75.3303	29.49	8.99	1940	2009	69
01478650	NEKD1	White Clay Creek at Newark	DE	39.6892	75.7489	56.45	17.21	1994	2009	15
01484525	99999	Millsboro Pond Outlet at Millsboro	DE	38.5944	75.2911	1.98	0.60	1986	2009	23
01474500	99999	Schuylkill River at Philadelphia	PA	39.9678	75.1889	5.74	1.75	1931	2009	78
01477000	CHSP1	Chester Creek Near Chester	PA	39.8689	75.4086	23.41	7.14	1931	2009	78
01411500	99999	Maurice River at Norma	NJ	39.4956	75.0769	49.94	15.22	1932	2009	77
01463500	TREN4	Delaware River at Trenton	NJ	40.2217	74.7781	0.00	0.00	1912	2009	97
01465500	LNGP1	Neshaminy Creek near Langhorne	PA	40.1739	74.9572	40.57	12.37	1934	2009	75
01467087	99999	Frankford Creek at Castor Ave.	PA	40.0158	75.0972	16.56	5.05	1982	2009	27

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF ID for that USGS gauge
[2] Referenced to horizontal control datum NAD27
[3] Referenced to vertical geodetic datum NGVD29

Each USGS river gauge has its own climatology file with the naming convention *USGS_StationID_Dailymean_Dsch-Temp.dat* where StationID is the USGS station ID.

The daily mean river discharge and water temperature climatologies for each USGS station along with the daily climatologies for stations used by other two OFSs are included in a single netCDF file called *nos.ofs.river.climo.usgs.nc*. This is the file used for the operational nowcast/forecast cycles of the three OFSs.

2.4. CBOFS

CBOFS daily mean river discharge and water temperature climatologies were created for 26 USGS river gauge locations necessary for CBOFS (Figure 4). For CBOFS, a daily mean salinity climatology was also created at a few gauges to provide an estimate of salinity at USGS gauges when near-real-time conductivity observations are not available. The river gauges selected for CBOFS were provided by Lanerolle (2009) of NOS/CSDL. Geographic information on the 26 gauges along with information on the length of the observation record used to create the climatology is given in Table 3.

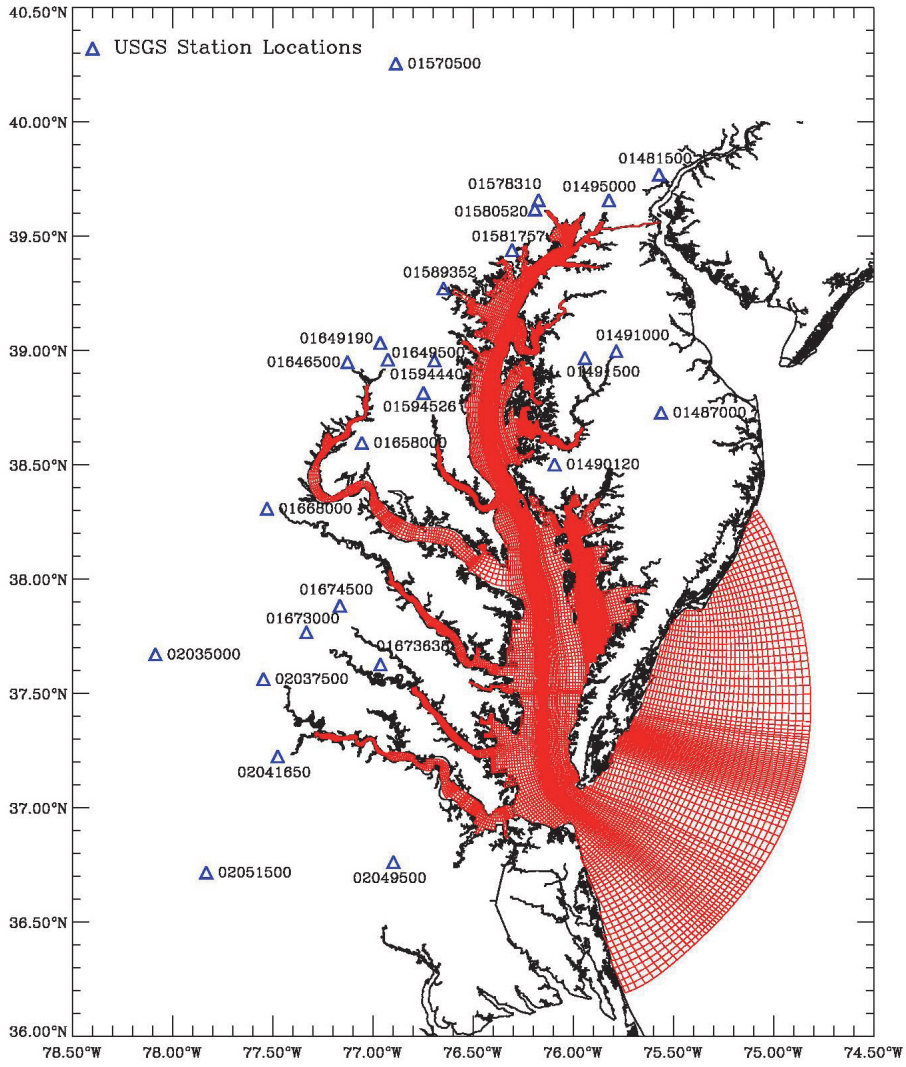

Figure 4. Map depicting the ROMS grid used for CBOFS along with locations of the 26 USGS river stations where discharge and water temperature climatologies were created for CBOFS. Salinity climatologies were created at few of these stations. The 26 stations were used for hindcast runs and are used in the four times/day operational nowcast/forecast cycles.

Table 3. Information on 26 USGS River Gauges at which mean daily river discharge and/or water temperature climatologies were created for CBOFS.

USGS Station ID	NWS SHEF ID [1]	Gauge Station Name	State/ Prv.	Latitude (degrees)[2]	Longitude (degrees)[2]	Elevation (above MSL) [3]		Start Year	End Year	No. of Years
						Feet	Meters			
01481500	WMND1	Brandywine Creek at Wilmington	DE	39.7694	75.5733	68.23	20.80	1946	2009	63
01487000	99999	Nanticoke River near Bridgeville	DE	38.7283	75.5619	13.64	4.16	1943	2009	66
01490120	99999	Little Blackwater River near Cambridge	MD	38.5017	76.0942	-1.25	-0.38	2006	2008	2
01491000	99999	Choptank River near Greensboro	MD	38.9972	75.7858	3.51	1.07	1948	2009	61
01491500	99999	Choptank River near Ruthsburg	MD	38.9669	75.9431	10.00	3.05	1951	2009	58
01495000	99999	Big Elk Creek at Elk Mills	MD	39.6569	75.8225	68.69	20.94	1932	2009	77
01570500	HARP1	Susquehanna River at Harrisburg	PA	40.2547	76.8864	290.01	88.40	1890	2009	119
01578310	CNWM2	Susquehanna River at Conowingo	MD	39.6578	76.1744	5.00	1.52	1967	2009	42
01580520	99999	Deer Creek near Darlington	MD	39.6175	76.1919	50.00	15.24	2000	2009	9
01581757	99999	Otter Point Creek near Edgewood	MD	39.4392	76.3061	5.00	1.52	2000	2009	9
01589352	99999	Gwynns Falls at Washington Blvd.	MD	39.2714	76.6486	10.00	3.05	1998	2009	11
01594440	99999	Patuxent River near Bowie	MD	38.9558	76.6936	13.10	3.99	1977	2009	32
01594526	99999	Western Branch at Upper Marlboro	MD	38.8142	76.7486	26.90	8.20	1985	2009	24
01646500	BRKM2	Potomac River near Washington	DC	38.9497	77.1278	37.95	11.57	1930	2009	79
01649190	99999	Paint Branch near College Park	MD	39.0331	76.9642	150.00	45.72	2007	2009	2
01649500	99999	NE Branch Anacostia River at Riverdale	MD	38.9603	76.9261	12.68	3.86	1938	2009	71
01658000	99999	Mattawoman Creek near Pomonkey	MD	38.5961	77.0561	40.00	12.19	1949	2009	60
01668000	FDBV2	Rappahannock River near Fredericksburg	VA	38.3083	77.5294	70.00	21.34	1907	2009	102
01673000	99999	Pamunkey River near Hanover	VA	37.7675	77.3325	14.72	4.49	1941	2009	68
01673638	99999	Cohoke Mill Creek near Lester Manor	VA	37.6267	76.9628	40.00	12.19	1998	2009	11
01674500	99999	Mattaponi River near Beulahville	VA	37.8839	77.1653	12.43	3.79	1941	2009	68
02035000	CARV2	James River at Cartersville	VA	37.6708	78.0861	163.90	49.96	1898	2009	111
02037500	RMDV2	James River near Richmond	VA	37.5631	77.5472	98.82	30.12	1934	2009	75
02041650	MTCV2	Appomattox River at Matoaca	VA	37.2250	77.4756	68.30	20.82	1969	2009	40
02049500	FKNV2	Blackwater River near Franklin	VA	36.7625	76.8986	1.56	0.48	1944	2009	65
02051500	LAWV2	Meherrin River near Lawrenceville	VA	36.7167	77.8319	136.56	41.62	1929	2009	80

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF ID for that USGS gauge
[2] Referenced to horizontal control datum NAD27
[3] Referenced to vertical geodetic datum NGVD29

The daily mean climatology for each USGS river gauge is contained in a text file with the naming convention *USGS_StationID_Dailymean_Dsch-Temp.dat* where StationID is the USGS station ID.

The daily mean river discharge, water temperature, and salinity climatologies for each USGS station along with the daily climatologies for stations used by other two OFSs are included in a single netCDF file called *nos.ofs.river.climo.usgs.nc*. This is the file used for the operational nowcast/forecast cycles of the three OFSs.

3. MEAN ANNUAL AND EXTREMA DISCHARGE CLIMATOLOGY

3.1. Description

A mean annual and extrema river discharge climatology was developed to provide threshold values for the quality control of near real-time river observations at USGS river gauge stations. For every river gauge, the climatology has three values: minimum, mean, and maximum discharge. If real-time discharge observations from a USGS river gauge are less than the minimum, or greater than the maximum values of that specific gauge, then the OFS will use the mean river discharge climatology.

The river discharge mean annual and extrema climatologies were created using historical data from USGS using one of two methods: observed and estimated. The observed method used the mean discharge climatology available from a report published annually by USGS. The mean, maximum and minimum values were converted from cubic feet per second to cubic meters per second using the conversion: $1\ ft^3/s = 0.0283\ m^3/s$.

The estimated method was used when USGS didn't provide a report for that river, or the real-time data was collected for less than ten years or discontinuously. The estimated method involved creating the mean discharge by averaging the daily mean discharge values for the entire lifespan of the given gauge. The minimum and maximum values for the climatology were obtained by selecting the highest and lowest values from the daily minimum and maximum discharge values covering the entire lifespan of each gauge. All units were converted into cubic meters per second using the conversion stated earlier.

The mean annual and extrema discharge climatology for all the gauges used a particular OFS are contained in Section 1 of the OFS's river control text file. The names of the river control files are *nos.cbofs.river.ctl*, *nos.dbofs.river.ctl*, and *nos.tbofs.river.ctl* and are given in Appendix A.

3.2. TBOFS

Mean annual and extrema river discharge climatology was created for 17 USGS river gauge locations necessary for TBOFS. The river gauges selected for TBOFS were provided by Wei (2009) of NOS/CSDL. Information about the 17 stations along with information on the length of the observation record used to create the climatology is given in Table 4.

Table 4. Information on the 17 USGS river discharge gauges at which mean annual and extrema river discharge climatologies were created for TBOFS.

USGS Station ID	NWS SHEF ID [1]	Gauge Station Name	State/ Prv.	Latitude (degrees)[2]	Longitude (degrees)[2]	Elevation (above MSL)[3]		Start Year	End Year	No. of Years
						Feet	Meters			
02299950	MKHF1	Manatee River near Myakka Head	FL	27.4733	82.2114	40.93	12.48	1966	2009	43
02300021 *	99999	Manatee River at Fort Hamer	FL	27.5181	82.4283	0.00	0.00	2006	2009	3
02300033 *	99999	Braden River at Lakewood Ranch	FL	27.4206	82.4261	-3.79	-1.16	2005	2009	4
02300210	99999	South Fork Little Manatee River	FL	27.6017	82.2114	53.84	16.41	2000	2009	9
02300500 *	99999	Little Manatee River near Wimauma	FL	27.6708	82.3528	0.00	0.00	1939	2009	70
02301719 *	99999	Alafia River near Gibsonton	FL	27.8567	82.3578	0.00	0.00	1999	2009	10
02303330	MORF1	Hillsborough River at Morris Bridge	FL	28.0986	82.3114	0.00	0.00	1972	2009	37
02304500	99999	Hillsborough River near Tampa	FL	28.0236	82.4278	0.00	0.00	1938	2009	71
02304510 *	99999	Hillsborough River at Rowlett Park Dr.	FL	28.0208	82.4347	0.00	0.00	2003	2009	6
02306000 *	99999	Sulpher Springs at Sulpher Springs	FL	28.0208	82.4519	0.00	0.00	1959	2009	50
02306647 *	99999	Sweetwater Creek near Tampa	FL	28.0136	82.5453	0.00	0.00	1985	2009	24
02306774	99999	Rocky Creek near Citrus Park	FL	28.0658	82.5658	0.00	0.00	1985	2009	24
02307359	99999	Brooker Creek near Tarpon Springs	FL	28.0958	82.6875	0.00	0.00	1950	2009	59
02307498	99999	Lake Tarpon Canal near Oldsmar	FL	28.0533	82.7111	-10.00	-3.05	1974	2009	35
02300700	99999	Bullfrog Creek near Wimauma	FL	27.7917	82.3522	0.00	0.00	1956	2009	53
02301802	99999	Tampa Bypass Canal at S-160	FL	27.9558	82.3708	0.00	0.00	1974	1990	16
02301750 *	99999	Delaney Creek near Tampa	FL	27.9256	82.3644	10.72	3.27	1984	2009	25

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge
[2] Referenced to horizontal control datum NAD27
[3] Referenced to vertical geodetic datum NGVD29
* Denotes stations used in the operational nowcast/forecast cycles

The discharge climatology (m^3/s) for each USGS river gauge in TBOFS are incorporated in a single file named *TBOFS_USGS_DSCH.dat* (Table 5). The mean annual and extrema climatological data are included in Section 1 of the TBOFS river control file called *nos.tbofs.river.ctl* (Figure 5). The control file contains discharge climatology for only eight gauges that are used in the four times/day operational nowcast/forecast cycles.

Table 5. The mean annual and extrema river discharge climatologies for the 17 USGS gauges used by TBOFS.

USGS Station ID	NWS SHEF ID [1]	Discharge (m^3/s)			Est./Obs.	Station Name
		Minimum	Maximum	Mean		
02299950	MKHF1	0.00	331.11	2.11	O	Manatee River near Myakka Head, FL
02300021 *	99999	-11.55	69.62	1.43	E	Manatee River at Fort Hamer, FL
02300033 *	99999	0.01	44.43	0.58	E	Braden River at Lakewood Ranch, FL
02300210	99999	0.00	67.35	0.76	E	South Fork Little Manatee River, FL
02300500 *	99999	0.03	396.20	4.81	O	Little Manatee River near Wimanma, FL
02300700	99999	0.00	147.16	1.22	O	Bullfrog Creek near Wimauma, FL
02301719 *	99999	-35.09	129.61	11.74	E	Alafia River near Gibsonton, FL
02301750 *	99999	0.00	20.40	0.26	O	Delaney Creek near Tampa, FL
02301802	99999	0.00	305.64	3.90	O	Tampa Bypass Cana at S-160, FL
02303330	MORF1	0.59	167.25	7.13	O	Hillsborough at Morris Bridge, FL
02304500	99999	0.00	74.71	5.77	O	Hillsborough near Tampa, FL
02304510 *	99999	-1.16	67.07	6.80	E	Hillsborough River at Rowlett Park Dr., FL
02306000 *	99999	0.00	4.10	1.01	O	Sulpher Springs at Sulpher Springs, FL
02306647 *	99999	0.00	26.32	0.58	O	Sweetwater Creek near Tampa, FL
02306774	99999	0.00	10.36	0.37	O	Rocky Creek near Citrus Park, FL
02307359	99999	0.00	45.28	0.51	O	Brooker Creek near Tarpon Springs, FL
02307498	99999	0.00	64.81	1.46	O	Lake Tarpon Canal near Oldsmar, FL

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge
* Denotes stations used by the operational nowcast/forecast cycles

```
Section 1: Information about USGS rivers where real-time discharges and temperature are available
15  8  1.0  !! NIJ NRIVERS DELT
RiverID  USGS_ID   NWS_ID    Q_min    Q_max  Q_mean   T_min   T_max   T_mean   Q_Flag  T_Flag       River_Station_Name
  1     02306000    XXXXX     0.00     4.10    1.01   23.90   25.80   -999.0     1       1       Sulphur Springs at Sulpher Springs, FL
  2     02301750    XXXXX     0.00    20.40    0.26    8.50   34.10   -999.0     1       1       Delaney Creek near Tampa, FL
  3     02301719    XXXXX     0.09   129.61   11.74    8.50   34.10   -999.0     1       1       Alafia River near Gibsonton, FL
  4     02300500    XXXXX     0.03   396.20    4.81   11.00   35.00    24.98     1       1       Little Manatee River at Wimauma, FL
  5     02300021    XXXXX     0.55    69.62    1.43   11.00   35.00    24.98     1       1       Manatee River at Fort Hamer, FL
  6     02300033    XXXXX     0.01    44.43    0.58   11.00   35.00    24.98     1       1       Braden River at Lakewood Ranch, FL
  7     02306647    XXXXX     0.00    26.32    0.58    9.60   33.50   -999.0     1       1       Sweetwater Creek near Tampa, FL
  8     02304510    XXXXX     0.00    67.07    6.80    9.60   33.50   -999.0     1       1       Hillsborough River at Rowlett Park Dr., FL
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Figure 5. Section 1 of the TBOFS river control file which incorporates mean and extreme minimum and maximum discharge and temperature values at eight USGS river gauges. Mean values listed as -999.0 indicate mean temperature data is unavailable at the station.

3.3. DBOFS

Mean annual and extrema river discharge climatological data for DBOFS were created for 11 river gauge locations necessary for DBOFS. The river gauges selected for DBOFS were provided by Schmalz (2009) of NOS/CSDL. Information about the 11 stations along with information on the length of the observation record used to create the climatology is given in Table 6.

Table 6. Information on the 11 USGS river discharge gauges at which mean annual and extrema river discharge climatologies were created for DBOFS.

USGS Station ID	NWS SHEF ID [1]	Gauge Station Name	State/ Prv.	Latitude (degrees)[2]	Longitude (degrees)[2]	Elevation (above MSL)[3]		Start Year	End Year	No. of Years
						Feet	Meters			
01412800	99999	Cohansey River at Seeley	NJ	39.4725	75.2556	26.90	8.20	1977	2009	32
01477120	99999	Raccoon Creek near Swedesboro	NJ	39.7406	75.2592	0.00	0.00	1966	2009	43
01482500	99999	Salem River at Woodstown	NJ	39.6439	75.3303	29.49	8.99	1940	2009	69
01478650	NEKD1	White Clay Creek at Newark	DE	39.6892	75.7489	56.45	17.21	1994	2009	15
01484525	99999	Millsboro Pond Outlet at Millsboro	DE	38.5944	75.2911	1.98	0.60	1986	2009	23
01474500	99999	Schuylkill River at Philadelphia	PA	39.9678	75.1889	5.74	1.75	1931	2009	78
01477000	CHSP1	Chester Creek Near Chester	PA	39.8689	75.4086	23.41	7.14	1931	2009	78
01411500	99999	Maurice River at Norma	NJ	39.4956	75.0769	49.94	15.22	1932	2009	77
01463500	TREN4	Delaware River at Trenton	NJ	40.2217	74.7781	0.00	0.00	1912	2009	97
01465500	LNGP1	Neshaminy Creek near Langhorne	PA	40.1739	74.9572	40.57	12.37	1934	2009	75
01467087	99999	Frankford Creek at Castor Ave.	PA	40.0158	75.0972	16.56	5.05	1982	2009	27

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge.
[2] Referenced to horizontal control datum NAD27
[3] Referenced to vertical geodetic datum NGVD29

The discharge climatology (m^3/s) for each USGS river gauge used by DBOFS is incorporated in a single file with the naming convention *DBOFS_USGS_DSCH.dat* (Table 7). The mean annual and extrema climatological data for all 11 gauges are included in Section 1 of the DBOFS river control file called *nos.dbofs.river.ctl* (Figure 6).

Table 7. The mean annual and extrema river discharge climatologies for the 11 USGS gauges used by DBOFS.

USGS Station ID	NWS SHEF ID [1]	Discharge (m^3/s)			Est./Obs.	Station Name
		Minimum	Maximum	Mean		
01412800	99999	0.13	283.00	1.01	O	Cohansey River at Seeley, NJ
01477120	99999	0.08	99.90	1.12	O	Raccoon Creek near Swedesboro, NJ
01482500	99999	0.00	622.60	0.55	O	Salem River at Woodstown, NJ
01478650	NEKD1	0.07	475.44	2.69	O	White Clay Creek at Newark, DE
01484525	99999	0.00	50.09	2.62	O	Millsboro Pond Outlet at Millsboro, DE
01474500	99999	0.00	2914.90	79.24	O	Schuylkill Rive at Philadelphia, PA
01477000	CHSP1	0.01	594.30	2.61	O	Chester Creek Near Chester, PA
01411500	99999	0.25	208.29	4.61	O	Maurice River at Norma, NJ
01463500	TREN4	33.39	9310.70	336.77	O	Delaware River at Trenton, NJ
01465500	LNGP1	0.05	1395.19	8.66	O	Neshaminy Creek near Langhorne, PA
01467087	99999	0.01	393.37	1.17	O	Frankford Creek at Castor Ave., PA

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge.

```
Section 1:  Information about USGS rivers where real-time discharges are available
14  11  1.0 !! NIJ NRIVERS DELT: number of model locations (NIJ) and number of USGS river stations (NRIVERS)
RiverID  USGS_ID   NWS_ID   Q_min    Q_max   Q_mean   T_min   T_max  T_mean   Q_Flag  T_Flag       River_Station_Name
   1     01411500    XXXXX    0.25   208.29     4.61    0.00   27.50   13.62     1       1       Maurice River at Norma, NJ
   2     01412800    XXXXX    0.13   283.00     1.01    0.00   27.50   13.62     1       1       Cohansey River at Seeley, NJ
   3     01463500    TREN4   33.39  9310.70   336.77   -0.60   34.00   13.42     1       1       Delaware River at Trenton, NJ
   4     01465500    LNGP1    0.05  1395.19     8.66   -0.60   34.00   13.42     1       1       Neshaminy Creek near Langhorne, PA
   5     01467087    XXXXX    0.01   393.37     1.17   -0.60   34.00   13.42     1       1       Frankford Creek at Castor Ave., PA
   6     01474500    XXXXX    0.00  2914.90    79.24    0.00   27.50   13.62     1       1       Schuylkill River at Philadelphia, PA
   7     01477120    XXXXX    0.08    99.90     1.12    0.00   27.50   13.62     1       1       Raccoon Creek near Swedesboro, NJ
   8     01478650    NEKD1    0.07   475.44     2.69    0.00   27.50   13.62     1       1       White Clay Creek at Newark, DE
   9     01482500    XXXXX    0.00   622.60     0.55    0.00   27.50   13.62     1       1       Salem River at Woodstown, NJ
  10     01484525    XXXXX    0.00    50.09     2.62    0.00   27.50   13.62     1       1       Millsboro Pond Outlet at Millsboro, DE
  11     01477000    CHSP1    0.01   393.37     1.17   -0.60   34.00   13.42     1       1       Chester Creek near Chester, PA
```

Figure 6. Section 1 of the DBOFS river control file which incorporates mean and extreme minimum and maximum discharge and temperature values at the 11 USGS river gauges.

3.4. CBOFS

Mean annual and extrema river discharge climatological data for CBOFS were created for 18 river gauge locations necessary for CBOFS. The river gauges used for CBOFS were provided by Lanerolle (2009) of NOS/CSDL. Information about the 24 stations along with information on the length of the observation record used to create the climatology is given in Table 8.

Table 8. Information on the 24 USGS river discharge gauges at which mean annual and extrema river discharge climatologies were created for CBOFS.

USGS Station ID	NWS SHEF ID [1]	Gauge Station Name	State/ Prv.	Latitude (degrees)[2]	Longitude (degrees)[2]	Elevation (above MSL)[3]		Start Year	End Year	No. of Years
						Feet	Meters			
01481500 ‡	WMND	Brandywine Creek at Wilmington	DE	39.7694	75.5733	68.23	20.80	1946	2009	63
01487000	99999	Nanticoke River near Bridgeville	DE	38.7283	75.5619	13.64	4.16	1943	2009	66
01491000	99999	Choptank River near Greensboro	MD	38.9972	75.7858	3.51	1.07	1948	2009	61
01491500	99999	Choptank River near Ruthsburg	MD	38.9669	75.9431	10.00	3.05	1951	2009	58
01495000	99999	Big Elk Creek at Elk Mills	MD	39.6569	75.8225	68.69	20.94	1932	2009	77
01570500 ‡	HARP1	Susquehanna River at Harrisburg	PA	40.2547	76.8864	290.01	88.40	1890	2009	119
01578310	CNWM2	Susquehanna River at Conowingo	MD	39.6578	76.1744	5.00	1.52	1967	2009	42
01580520	99999	Deer Creek near Darlington	MD	39.6175	76.1919	50.00	15.24	2000	2009	9
01581757	99999	Otter Point Creek near Edgewood	MD	39.4392	76.3061	5.00	1.52	2000	2009	9
01589352	99999	Gwynns Falls at Washington Blvd	MD	39.2714	76.6486	10.00	3.05	1998	2009	11
01594440	99999	Patuxent River near Bowie	MD	38.9558	76.6936	13.10	3.99	1977	2009	32
01594526	99999	Western Branch at Upper Marlboro	MD	38.8142	76.7486	26.90	8.20	1985	2009	24
01646500	BRKM2	Potomac River near Washington	DC	38.9497	77.1278	37.95	11.57	1930	2009	79
01649500 ‡	99999	NE Branch Anacostia River at Riverdale	MD	38.9603	76.9261	12.68	3.86	1938	2009	71
01658000	99999	Mattawoman Creek near Pomonkey	MD	38.5961	77.0561	40.00	12.19	1949	2009	60
01668000	FDBV2	Rappahannock River near Fredericksburg	VA	38.3083	77.5294	70.00	21.34	1907	2009	102
01673000	99999	Pamunkey River near Hanover	VA	37.7675	77.3325	14.72	4.49	1941	2009	68
01673638 ‡	99999	Cohoke Mill Creek near Lester Manor	VA	37.6267	76.9628	40.00	12.19	1998	2009	11
01674500	99999	Mattaponi River near Beulahville	VA	37.8839	77.1653	12.43	3.79	1941	2009	68
02035000 ‡	CARV2	James River at Cartersville	VA	37.6708	78.0861	163.90	49.96	1898	2009	110
02037500	RMDV2	James River near Richmond	VA	37.5631	77.5472	98.82	30.12	1934	2009	75
02041650	MTCV2	Appomattox River at Matoaca	VA	37.2250	77.4756	68.30	20.82	1969	2009	40
02049500	FKNV2	Blackwater River near Franklin	VA	36.7625	76.8986	1.56	0.48	1944	2009	65
02051500 ‡	LAWV2	Meherrin River near Lawrenceville	VA	36.7167	77.8319	136.56	41.62	1929	2009	80

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge.
[2] Referenced to horizontal control datum NAD27
[3] Referenced to vertical geodetic datum NGVD29
‡ Denotes the water temperature climatological data at this USGS gauge are not be used in the operational nowcast/forecast cycles

The mean/extrema discharge climatology (m^3/s) for each USGS river gauge in CBOFS is incorporated in a single file with the naming convention *CBOFS_USGS_DSCH.dat* (Table 9). The climatology is included in Section 1 of the CBOFS river control file called *nos.cbofs.river.ctl* (Figure 7). The control file contains discharge climatology for 24 gauges. However, only 18 are used in the four times/day operational nowcast/forecast cycles since some rivers were merged in CBOFS.

Table 9. The mean annual and extrema river discharge climatologies for the 24 USGS gauges used by CBOFS.

USGS Station ID	NWS SHEF ID [1]	Discharge (m^3/s)			Est./Obs.	Station Name
		Minimum	Maximum	Mean		
01481500 ‡	WMND1	0.91	812.21	14.21	O	Brandywine Creek at Wilmington, DE
01487000	99999	0.18	85.47	2.64	O	Nanticoke River near Bridgeville, DE
01491000	99999	0.01	197.25	3.85	O	Choptank River near Greensboro, MD
01491500	99999	0.04	95.94	2.74	O	Choptank River near Ruthsburg, MD
01495000	99999	0.06	299.98	1.98	O	Big Elk Creek at Elk Mills, MD
01570500 ‡	HARP	45.28	28866.00	977.48	O	Susquehanna River at Harrisburg, PA
01578310	CNWM2	4.08	31979.00	1161.15	O	Susquehanna River at Conowingo, MD
01580520	99999	1.25	328.28	7.05	E	Deer Creek near Darlington, MD
01581757	99999	0.20	254.13	2.59	E	Otter Point Creek near Edgewood, MD
01589352	99999	0.18	676.37	2.55	E	Gwynns Falls at Washington Blvd., MD
01594440	99999	0.91	880.13	10.81	O	Patuxent River near Bowie, MD
01594526	99999	0.01	919.75	2.89	O	Western Branch at Upper Marlboro, MD
01646500	BRKM2	1.87	13697.20	323.19	O	Potomac River near Washington, DC
01649500 ‡	99999	0.04	339.60	2.48	O	NE Branch Anacostia River at Riverdale, MD
01658000	99999	0.00	263.19	1.62	O	Mattawoman Creek near Pomonkey, MD
01668000	FDBV2	0.14	3962.00	47.37	O	Rappahannock River near Fredericksburg, VA
01673000	99999	0.57	846.17	29.83	O	Pamunkey River near Hanover, VA
01673638 ‡	99999	0.00	40.47	0.20	O	Cohoke Mill Creek near Lester Manor. VA
01674500	99999	0.01	478.27	16.10	O	Mattaponi River near Beulahville, VA
02035000 ‡	CARV2	8.94	10244.60	198.86	O	James River at Cartersville, VA
02037500	RMDV2	0.28	8857.90	193.43	O	James River near Richmond, VA
02041650	MTCV2	0.48	1154.64	37.30	O	Appomattox River at Matoaca, VA
02049500	FKNV2	0.00	650.90	18.03	O	Blackwater River near Franklin, VA
02051500 ‡	99999	0.06	1075.40	14.07	O	Meherrin River near Lawrenceville, VA

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge
‡ Denotes the water temperature climatological data at this USGS gauge are not used in the operational nowcast/forecast cycles

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Section 1:  Information about USGS rivers where real-time discharges are available
51  26  1.0 !! NIJ NRIVERS : number of model locations (NIJ) and number of USGS river stations (NRIVERS)
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RiverID	USGS_ID	NWS_ID	Q_min	Q_max	Q_mean	T_min	T_max	T_mean	Q_Flag	TS_Flag	River_Station_Name
1	01487000	XXXXX	0.18	85.47	2.64	0.80	27.90	15.06	1	1	Nanticoke River near Bridgeville, DE
2	01491000	XXXXX	0.01	197.25	3.85	-999.0	-999.0	-999.0	1	0	Choptank River near Greensboro, MD
3	01491500	XXXXX	0.04	95.94	2.74	0.00	29.20	13.65	1	0	Choptank River near Ruthsburg, MD
4	01495000	XXXXX	0.06	299.98	1.98	-999.0	-999.0	-999.0	1	0	Big Elk Creek at Elk Mills, MD
5	01578310	CNWM2	4.08	31979.00	1161.15	-999.0	-999.0	-999.0	1	0	Susquehanna River at Conowingo, MD
6	01580520	XXXXX	1.25	328.28	7.05	-999.0	-999.0	-999.0	1	0	Deer Creek near Darlington, MD
7	01581757	XXXXX	0.20	254.13	2.59	-999.0	-999.0	-999.0	1	0	Otter Point Creek near Edgewood, MD
8	01589352	XXXXX	0.18	676.37	2.55	-999.0	-999.0	-999.0	1	0	Gwynns Falls at Washington Blvd., MD
9	01646500	BRKM2	1.87	13697.20	323.19	-0.30	34.00	15.55	1	1	Potomac River near Washington, DC
10	01658000	XXXXX	0.00	263.19	1.62	-0.10	29.10	13.55	1	1	Mattawoman Creek near Pomonkey, MD
11	01594440	XXXXX	0.91	880.13	10.81	-999.0	-999.0	-999.0	1	0	Patuxent River near Bowie, MD
12	01594526	XXXXX	0.01	919.75	2.89	-999.0	-999.0	-999.0	1	0	Western Branch at Upper Marlboro, MD
13	01668000	FDBV2	0.14	3962.00	47.37	-0.10	34.40	15.71	1	1	Rappahannock River near Fredericksburg, VA
14	01673000	XXXXX	0.57	846.17	29.83	-0.10	32.20	15.45	1	0	Pamunkey River near Hanover, VA
15	01674500	XXXXX	0.01	478.27	16.10	0.00	30.00	15.00	1	0	Mattaponi River near Beulahville, VA
16	02037500	RMDV2	0.28	8857.90	193.43	-999.0	-999.0	-999.0	1	0	James River near Richmond, VA
17	02041650	MTCV2	0.48	1154.64	37.30	-999.0	-999.0	-999.0	1	0	Appomattox River at Matoaca, VA
18	02049500	FKNV2	0.00	650.90	18.03	-999.0	-999.0	-999.0	1	0	Blackwater River near Franklin, VA
19	02051500	XXXXX	0.06	1075.40	14.07	-0.20	29.90	15.20	0	1	Meherrin River near Lawrenceville, VA
20	02035000	XXXXX	8.94	10244.60	198.86	-0.50	36.00	15.77	0	1	James River at Cartersville, VA
21	01673638	XXXXX	0.00	40.47	0.20	0.10	34.00	15.77	0	1	Cohoke Mill Creek near Lester Manor, VA
22	01649500	XXXXX	0.04	339.60	2.48	-0.20	32.20	14.20	0	1	NE Branch Anacostia River at Riverdale, MD
23	01649190	XXXXX	-999.0	-999.0	-999.0	-0.20	25.50	10.91	0	1	Paint Branch near College Park, MD
24	01570500	XXXXX	45.28	28866.00	977.48	0.00	32.00	12.93	0	1	Susquehanna River at Harrisburg, PA
25	01481500	XXXXX	0.91	812.21	14.21	0.00	29.20	13.65	0	1	Brandywine Creek at Wilmington, DE
26	01490120	XXXXX	-999.0	-999.0	-999.0	-0.30	35.20	17.27	0	1	Little Blackwater River near Cambridge, MD

Figure 7. Section 1 of the CBOFS river control file which incorporates mean and extreme minimum and maximum discharge and temperature values at 24 USGS river gauges. Mean and extreme values listed as -999.0 indicate no discharge or temperature measurement at the station.

4. MEAN ANNUAL AND EXTREMA WATER TEMPERATURE CLIMATOLOGY

4.1. Description

A mean annual and extrema river water temperature climatology was developed to provide threshold values for the quality control of near real-time river observations at USGS river gauge stations.

For every river gauge, the climatology has three values: minimum, mean, and maximum discharge. If real-time water temperature observations from a USGS river gauge are less than the minimum, or greater than the maximum values of that specific gauge, then the OFS could use the mean river water temperature climatology.

The river water temperature mean annual and extrema climatology was created using historical data from USGS using one of two methods: observed and estimated. The observed method used the mean water temperature climatology available from a report published annually by USGS.

The estimated method was used when USGS didn't provide a report for that river, or the real-time data was collected for less than ten years or discontinuously. The estimated method involved creating the mean water temperature by averaging the daily mean water temperature values for the entire lifespan of the given gauge. The minimum and maximum values for the climatology were obtained by selecting the highest and lowest values from the daily minimum and maximum water temperature values covering the entire lifespan of each gauge.

However, this annual water temperature climatology is not used by the three new OFSs when they became operational in September and October 2010. Instead, the OFS will rely on the HPC-COMF to perform QC by checking unusual temporal changes in water temperature observations and disregarding any observations which are 3 sigma from the mean for a selected time period. The river water temperature climatology may be used in future versions of these OFSs.

4.2. TBOFS

Mean annual and extrema river water temperature climatology for TBOFS was created for four river gauge locations necessary for TBOFS. The river gauges selected for TBOFS were provided by Wei (2009) of CSDL. Information about the four stations is provided in Table 10.

Table 10. Information on USGS river temperature gauges within or near the TBOFS grid domain.

USGS Station ID	NWS SHEF ID [1]	Gauge Station Name	State/ Prv.	Latitude [2] (degrees)	Longitude [2] (degrees)	Elevation (above MSL) [3]		Start Year	End Year	No. of Years
						Feet	Meter			
02300021 *	99999	Manatee River at Fort Hamer	FL	27.5181	82.4283	0.00	0.00	1997	2009	9 [a]
02301719 *	99999	Alafia River near Gibsonton	FL	27.8567	82.3578	0.00	0.00	1999	2009	10
02304510 *	99999	Hillsborough River at Rowlett Park Dr.	FL	28.0208	82.4347	0.00	0.00	1996	2009	13
02306000 *	99999	Sulpher Springs at Sulpher Springs	FL	28.0208	82.4519	0.00	0.00	1999	2009	10

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge
[2] Referenced to horizontal control datum NAD27
[3] Referenced to vertical geodetic datum NGVD29
* Denotes stations used in the four times/day operational nowcast/forecast cycles
[a] Denotes data is discontinuous

The mean annual/extrema river water temperature (^{o}C) climatological data for 17 USGS gauges are contained in the file called *TBOFS_USGS_TEMP.dat* (Table 11). Mean annual temperature and extreme values are referred from their nearest neighbor gauges at 13 other gauges since these gauges do not measure water temperature and the variations of temperature climatology among these gauges are relatively small. These temperature climatologies may be included in the TBOFS river control file in the future (Fig. B.1).

Table 11. The mean annual and extrema river water temperature climatologies created/referred at 17 USGS gauges for potential use by TBOFS.

USGS Station ID	NWS SHEF ID [1]	Temperature (^{o}C)			Est./Obs. (Station Referred)	Station Name
		Minimum	Maximum	Mean [2]		
02299950	MKHF1	11.00	35.00	24.98	02300021	Manatee River near Myakka Head, FL
02300021 *	99999	11.00	35.00	24.98	E	Manatee River at Fort Hamer, FL
02300033 *	99999	11.00	35.00	24.98	02300021	Braden River at Lakewood Ranch, FL
02300210	99999	11.00	35.00	24.98	02300021	South Fork Little Manatee River, FL
02300500 *	99999	11.00	35.00	24.98	02300021	Little Manatee River near Wimanma, FL
02300700	99999	8.50	34.10	-999	02301719	Bullfrog Creek near Wimauma, FL
02301719 *	99999	8.50	34.10	-999	O	Alafia River near Gibsonton, FL
02301750 *	99999	8.50	34.10	-999	02301719	Delaney Creek near Tampa, FL
02301802	99999	9.60	33.50	-999	02304510	Tampa Bypass Cana at S-160, FL
02303330	MORF1	9.60	33.50	-999	02304510	Hillsborough River at Morris Bridge, FL
02304500	99999	9.60	33.50	-999	02304510	Hillsborough River near Tampa, FL
02304510 *	99999	9.60	33.50	-999	O	Hillsborough River at Rowlett Park Dr., FL
02306000 *	99999	23.90	25.80	-999	O	Sulpher Springs at Sulpher Springs, FL
02306647 *	99999	9.60	33.50	-999	02304510	Sweetwater Creek near Tampa, FL
02306774	99999	9.60	33.50	-999	02304510	Rocky Creek near Citrus Park, FL
02307359	99999	9.60	33.50	-999	02304510	Brooker Creek near Tarpon Springs, FL
02307498	99999	9.60	33.50	-999	02304510	Lake Tarpon Canal near Oldsmar, FL

Notes:
[1] NWS SHEF ID 99999 denotes no current NWS SHEF ID for USGS gauge
[2] Mean value -999 denotes data is not available
* Denotes stations used in the operational nowcast/forecast cycles
E=estimated
O=observed

4.3. DBOFS

Mean annual and extrema river water temperature climatology for DBOFS was created for two USGS river gauge locations required by DBOFS. The river gauges selected for DBOFS were provided by Schmalz (2009) of CSDL. Information about the two stations is provided in Table 12.

Table 12. Information on USGS river temperature gauges within or near the DBOFS grid domain.

USGS Station ID	NWS SHEF ID [1]	Gauge Station Name	State/ Prv.	Latitude (degrees) [2]	Longitude (degrees) [2]	Elevation (above MSL) [3]		Start Year	End Year	No. of Years
						Fee	Meters			
01411500	99999	Maurice River at Norma	NJ	39.4956	75.0769	49.94	15.22	1966	1994	28
01463500	TREN4	Delaware River at Trenton	NJ	40.2217	74.7781	0.00	0.00	1944	2009	65

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge.
[2] Referenced to horizontal control datum NAD27
[3] Referenced to vertical geodetic datum NGVD29

The mean annual/extrema river water temperature (^{o}C) climatological data for 11 USGS gauges are contained in the file called *DBOFS_USGS_TEMP.dat* (Table 13). Mean annual temperature and extreme values are referred from their nearest neighbor gauges at 9 other gauges since these gauges do not measure water temperature and the variations of temperature climatology among these gauges are relatively small. These temperature climatologies may be included in the DBOFS river control file in the future (Fig. B.2).

Table 13. The mean annual and extrema river water temperature climatologies created/referred at 11 USGS gauges for potential use by DBOFS.

USGS Station ID	NWS SHEF ID [1]	Temperature (ºC)			Est./Obs. (Station Referred)	Station Name
		Minimum	Maximum	Mean		
01412800	99999	0.00	27.50	13.62	01411500	Cohansey River at Seeley, NJ
01477120	99999	0.00	27.50	13.62	01411500	Raccoon Creek near Swedesboro, NJ
01482500	99999	0.00	27.50	13.62	01411500	Salem River at Woodstown, NJ
01478650	NEKD1	0.00	27.50	13.62	01411500	White Clay Creek at Newark, DE
01484525	99999	0.00	27.50	13.62	01411500	Millsboro Pond Outlet at Millsboro, DE
01474500	99999	0.00	27.50	13.62	01411500	Schuylkill Rive at Philadelphia, PA
01477000	CHSP	-0.60	34.00	13.42	01463500	Chester Creek Near Chester, PA
01411500	99999	0.00	27.50	13.62	E	Maurice River at Norma, NJ
01463500	TREN4	-0.60	34.00	13.42	O	Delaware River at Trenton, NJ
01465500	LNGP1	-0.60	34.00	13.42	01463500	Neshaminy Creek near Langhorne, PA
01467087	99999	-0.60	34.00	13.42	01463500	Frankford Creek at Castor Ave., PA

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge.
E=estimated
O=observed

4.4. CBOFS

Mean annual and extrema river temperature climatology for CBOFS was created for 14 river gauge locations required by CBOFS (Table 14). The river gauges used for CBOFS were provided by Lanerolle (2009) of CSDL. Information about the 14 stations is provided in Table 14. The river temperature climatological data for reach of the 14 gauge locations (Table 15) are contained in the file called *CBOFS_USGS_TEMP.dat*.

Table 14. Information on 14 USGS river water temperature gauges within or near the CBOFS grid domain.

USGS Station ID	NWS SHEF ID [1]	Gauge Station Name	State/ Prv.	Latitude (degrees) [2]	Longitude (degrees) [2]	Elevation (above MSL) [3]		Start Year	End Year	No. of Years
						Feet	Meters			
01487000	99999	Nanticoke River near Bridgeville	DE	38.7283	75.5619	13.64	4.16	2006	2009	3
01481500	WMND1	Brandywine Creek at Wilmington	DE	39.7694	75.5733	68.23	20.80	2006	2009	3
01646500	BRKM2	Potomac River near Washington	DC	38.9497	77.1278	37.95	11.57	1988	2009	21
01658000	99999	Mattawoman Creek near Pomonkey	MD	38.5961	77.0561	40.00	12.19	2003	2009	6
01490120	99999	Little Blackwater River near Cambridge	MD	38.5017	76.0942	-1.25	-0.38	2006	2009	3
01649500	99999	NE Branch Anacostia River at Riverdale	MD	38.9603	76.9261	12.68	3.86	2003	2009	4 [a]
01649190	99999	Paint Branch near College Park	MD	39.0331	76.9642	150.00	45.72	2007	2009	2
01570500	HARP1	Susquehanna River at Harrisburg	PA	40.2547	76.8864	290.01	88.40	1945	2009	35 [a]
01668000	FDBV2	Rappahannock River near Fredericksburg	VA	38.3083	77.5294	70.00	21.34	1955	2009	11 [a]
01673000 ‡	99999	Pamunkey River near Hanover	VA	37.7675	77.3325	14.72	4.49	1945	2009	11 [a]
01673638	99999	Cohoke Mill Creek near Lester Manor	VA	37.6267	76.9628	40.00	12.19	2007	2009	2
01674500 ‡	99999	Mattaponi River near Beulahville	VA	37.8839	77.1653	12.43	3.79	1991	2009	6 [a]
02035000	CARV2	James River at Cartersville	VA	37.6708	78.0861	163.90	49.96	1968	2009	18 [a]
02051500	LAWV2	Meherrin River near Lawrenceville	VA	36.7176	77.8319	136.56	41.62	2006	2009	3

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF ID for that USGS gauge
[2] Referenced to horizontal control datum NAD27
[3] Referenced to vertical geodetic datum NGVD29
[a] Denotes historical data were discontinuous
‡ Denotes the water temperature climatological data at this USGS gauge are used in the operational nowcast/forecast cycles
E=estimated
O=observed

The mean annual/extrema river water temperature ($^{\circ}$C) climatological data for 14 USGS gauges are contained in the file called C*BOFS_USGS_TEMP.dat* (Table 15). The temperature climatologies may be included in the CBOFS river control file in the future (Fig. B.3).

Table 15. The mean annual and extrema river water temperature climatologies created at 14 USGS gauges for potential use by CBOFS.

USGS Station ID	NWS SHEF ID [1]	Temperature (ºC)			Est./Obs.	Station Name
		Minimum	Maximum	Mean		
01487000	99999	0.80	27.90	15.06	E	Nanticoke River near Bridgeville, DE
01481500	WMND1	0.00	29.20	13.65	E	Brandywine Creek at Wilmington, DE
01646500	BRKM2	-0.30	34.00	15.55	O	Potomac River near Washington, DC
01658000	99999	-0.10	29.10	13.55	E	Mattawoman Creek near Pomonkey, MD
01490120	99999	-0.30	35.20	17.27	E	Little Blackwater River near Cambridge, MD
01649500	99999	-0.20	32.20	14.20	E	NE Branch Anacostia River at Riverdale, MD
01649190	99999	-0.20	25.50	10.91	E	Paint Branch near College Park, MD
01570500	HARP1	0.00	32.00	12.93	O	Susquehanna River at Harrisburg, PA
01668000	FDBV2	-0.10	34.40	15.71	E	Rappahannock River near Fredericksburg, VA
01673000 ‡	99999	-0.10	32.20	15.45	E	Pamunkey River near Hanover, VA
01673638	99999	0.10	34.00	15.77	E	Cohoke Mill Creek near Lester Manor, VA
01674500 ‡	99999	0.00	30.00	15.00	E	Mattaponi River near Beulahville, VA
02035000	CARV2	-0.50	36.00	15.77	E	James River at Cartersville, VA
02051500	LAWV2	-0.20	29.90	15.20	E	Meherrin River near Lawrenceville, VA

Notes:
[1] NWS SHEF ID of 99999 denotes no current NWS SHEF station ID for that USGS gauge
‡ Denotes the water temperature climatological data at this USGS gauge are not used in the operational nowcast/forecast cycles

5. SUMMARY

Five different river climatologies were created to support the operations of three new NOS operational oceanographic forecast modeling systems. These five climatologies included: 1) daily mean river discharge climatology, 2) daily mean water temperature climatology, 3) daily mean salinity (for CBOFS only), 4) mean annual and extrema river discharge climatology, and 5) mean annual and extrema river water temperature climatology.

However, when the three ROMS-based OFSs became operational in Autumn 2010, only the 1) daily mean river discharge and water climatology and 2) mean annual and extrema river discharge climatology are used by the OFSs.

The daily mean river discharge and water climatologies will be used a backup by HPC-COMF software if no real-time observations are available at any USGS station. These climatologies are contained in a single netCDF file named *nos.ofs.river.clim.usgs.nc*. (The file also contains daily mean salinity climatology at CBOFS' USGS gauges but this information is not used by CBOFS.)

The mean annual and extrema river discharge will be used by HPC-COMF data preparation software to QC the real-time river observations. This climatology is contained in Section 1 of the individual river control text files for each OFS, *nos.cbofs.river.ctl*, *nos.dbofs.river.ctl*, and *nos.tbofs.river.ctl*

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Appendix A. Present Versions of River Control Files

Section 1: Information about USGS rivers where real-time discharges and temperature are available

15 8 1.0 !! NIJ NRIVERS DELT

RiverID	USGS_ID	NWS_ID	Q_min	Q_max	Q_mean	T_min	T_max	T_mean	Q_Flag	T_Flag	River_Station_Name
1	02306000	XXXXX	0.00	4.10	1.01	23.90	25.80	-999.0	1	1	Sulphur Springs at Sulpher Springs, FL
2	02301750	XXXXX	0.00	20.40	0.26	8.50	34.10	-999.0	1	1	Delaney Creek near Tampa, FL
3	02301719	XXXXX	0.09	129.61	11.74	8.50	34.10	-999.0	1	1	Alafia River near Gibsonton, FL
4	02300500	XXXXX	0.03	396.20	4.81	11.00	35.00	24.98	1	1	Little Manatee River at Wimauma, FL
5	02300021	XXXXX	0.55	69.62	1.43	11.00	35.00	24.98	1	1	Manatee River at Fort Hamer, FL
6	02300033	XXXXX	0.01	44.43	0.58	11.00	35.00	24.98	1	1	Braden River at Lakewood Ranch, FL
7	02306647	XXXXX	0.00	26.32	0.58	9.60	33.50	-999.0	1	1	Sweetwater Creek near Tampa, FL
8	02304510	XXXXX	0.00	67.07	6.80	9.60	33.50	-999.0	1	1	Hillsborough River at Rowlett Park Dr., FL

(a)

Section 2: Information of ROMS grids/locations to specify river inputs

GRID_ID	I/Xpos	J/Ypos	DIR	FLAG	RiverID_Q	Q_Scale	RiverID_T	T_Scale	River_Basin_Name
1	109	269	1	3	1	-1.50	8	1.00	Hillsborough and Sulphur springs, FL
2	110	269	1	3	1	-1.50	8	1.00	Hillsborough and Sulphur springs, FL
3	163	269	0	3	2	-1.00	8	1.00	Tampa Bypass Canal
4	163	270	0	3	2	-1.00	8	1.00	Tampa Bypass Canal
5	176	217	0	3	3	-1.00	3	1.00	Alafia and Bullfrog
6	176	218	0	3	3	-1.00	3	1.00	Alafia and Bullfrog
7	157	157	0	3	4	-0.50	3	1.00	Little Manatee at Wimanma
8	157	158	0	3	4	-0.50	3	1.00	Little Manatee at Wimanma
9	175	102	0	3	5	-0.40	5	1.00	Manatee at Myakka Head
10	175	103	0	3	5	-0.40	5	1.00	Manatee at Myakka Head
11	175	104	0	3	5	-0.40	5	1.00	Manatee at Myakka Head
12	164	92	1	3	6	0.50	5	1.00	Braden at Lakewood
13	165	92	1	3	6	0.50	5	1.00	Braden at Lakewood
14	19	290	1	3	7	-2.50	8	1.00	Rocky Cr.,Lake Tarpon, Sweetwater
15	20	290	1	3	7	-2.50	8	1.00	Rocky Cr.,Lake Tarpon, Sweetwater

(b)

PARAMETER DEFINITION:

NIJ : Number of model grids to specify river discharges
NRIVERS : Number of USGS river observing stations
DELT : Time interval in hours for output time series
RiverID : Serial Identification number of USGS River
USGS_ID : USGS river Identification number
NWS_ID : NWS Identification number for USGS river
GRID_ID : Serial Identification number for Model grid location to specify river input
I/Xpos : XI-position of model grid at RHO-points
J/Ypos : ETA-position of model grid at RHO-points
DIR : River runoff direction. 0:along x/xi-axis; 1:along y/eta-axis
FLAG : River runoff trace flag. 0: all tracers (T & S) are off; 1: only T is on; 2: only S is on; 3: both T and S are on
RiverID_Q: RiverID in Section 1 which is used to specify river discharge at the corresponding model grid
RiverID_T: RiverID in Section 1 which is used to specify river temperature at the corresponding model grid
Q_Scale : Scaling factor of river discharge at the model grid
T_scale : Scaling factor of river tempature at corresponding model grid
Q_min : Minimum discharge value of the river
Q_mean : Average discharge value of the river
Q_max : Maximum discharge value of the river
T_min : Minimum temperature value of the river
T_mean : Average temperature value of the river
T_max : Maximum temperature value of the river
Q_Flag : 0:use climatological river discharges data(daily mean); 1:use real-time river discharge observations
T_Flag : 0:use climatological temperature data(daily mean); 1:use real-time river temperature observations
River_Basin_Name: Name of Rivers or river basins
River_Station_Name: Name of Rivers or stations

(c)

Figure A.1 River control file for TBOFS, Section 1 (a), Section 2 (b) and Parameter Definitions (c).

Section 1: Information about USGS rivers where real-time discharges are available

14 11 1.0 !! NIJ NRIVERS DELT: number of model locations (NIJ) and number of USGS river stations (NRIVERS)

RiverID	USGS_ID	NWS_ID	Q_min	Q_max	Q_mean	T_min	T_max	T_mean	Q_Flag	T_Flag	River_Station_Name
1	01411500	XXXXX	0.25	208.29	4.61	0.00	27.50	13.62	1	1	Maurice River at Norma, NJ
2	01412800	XXXXX	0.13	283.00	1.01	0.00	27.50	13.62	1	1	Cohansey River at Seeley, NJ
3	01463500	TREN4	33.39	9310.70	336.77	-0.60	34.00	13.42	1	1	Delaware River at Trenton, NJ
4	01465500	LNGP1	0.05	1395.19	8.66	-0.60	34.00	13.42	1	1	Neshaminy Creek near Langhorne, PA
5	01467087	XXXXX	0.01	393.37	1.17	-0.60	34.00	13.42	1	1	Frankford Creek at Castor Ave., PA
6	01474500	XXXXX	0.00	2914.90	79.24	0.00	27.50	13.62	1	1	Schuylkill River at Philadelphia, PA
7	01477120	XXXXX	0.08	99.90	1.12	0.00	27.50	13.62	1	1	Raccoon Creek near Swedesboro, NJ
8	01478650	NEKD1	0.07	475.44	2.69	0.00	27.50	13.62	1	1	White Clay Creek at Newark, DE
9	01482500	XXXXX	0.00	622.60	0.55	0.00	27.50	13.62	1	1	Salem River at Woodstown, NJ
10	01484525	XXXXX	0.00	50.09	2.62	0.00	27.50	13.62	1	1	Millsboro Pond Outlet at Millsboro, DE
11	01477000	CHSP1	0.01	393.37	1.17	-0.60	34.00	13.42	1	1	Chester Creek near Chester, PA

(a)

Section 2: ROMS river discharge inputs

GRID_ID	I/Xpos	J/Ypos	DIR	FLAG	RiverID_Q	Q_Scale	RiverID_T	T_Scale	River_Basin_Name
1	94	92	0	3	1	-1.00	1	1.00	MAURICE RIVER
2	88	128	0	3	2	-1.00	1	1.00	COHANSEY RIVER
3	77	730	1	3	3	-0.33	3	1.00	DELAWARE RIVER
4	78	730	1	3	3	-0.34	3	1.00	DELAWARE RIVER
5	79	730	1	3	3	-0.33	3	1.00	DELAWARE RIVER
6	73	608	0	3	4	1.00	5	1.00	NESHAMINY CREEK
7	76	542	0	3	5	1.00	5	1.00	FRANKFORD CREEK
8	73	426	0	3	6	1.00	6	1.00	SCHUYLKILL RIVER
9	86	341	0	3	7	-1.00	6	1.00	RACCOON CREEK
10	73	283	0	3	8	1.20	6	1.00	BRANDYWINE CREEK
11	87	206	0	3	9	-1.00	6	1.00	SALEM RIVER
12	65	52	0	3	10	1.00	6	1.00	MILLSBORO POND
13	73	349	0	3	11	1.00	6	1.00	CHESTER CREEK
14	67	96	0	3	10	0.25	6	1.00	ROACH MARSH

(b)

PARAMETER DEFINITION:

NIJ   : Number of model grids to specify river discharges
NRIVERS : Number of USGS river observing stations
DELT   : Time interval in hours for output time series
RiverID : Serial Identification number of USGS River
USGS_ID : USGS river Identification number
NWS_ID   : NWS Identification number for USGS river
GRID_ID : Serial Identification number for Model grid location to specify river input
I/Xpos   : XI-position of model grid at RHO-points
J/Ypos   : ETA-position of model grid at RHO-points
DIR   : River runoff direction. 0:along x/xi-axis; 1:along y/eta-axis
FLAG   : River runoff trace flag. 0: all tracers (T & S) are off; 1: only T is on; 2: only S is on; 3: both T and S are on
RiverID_Q: RiverID in Section 1 which is used to specify river discharge at the corresponding model grid
RiverID_T: RiverID in Section 1 which is used to specify river temperature at the corresponding model grid
Q_Scale : Scaling factor of river discharge at the model grid
T_Scale : Scaling factor of river tempature at corresponding model grid
Q_min   : Minimum discharge value of the river
Q_mean   : Average discharge value of the river
Q_max   : Maximum discharge value of the river
T_min   : Minimum temperature value of the river
T_mean   : Average temperature value of the river
T_max   : Maximum temperature value of the river
Q_Flag   : 0:use climatological river discharges data(daily mean); 1:use real-time river discharge observations
T_Flag   : 0:use climatological temperature data(daily mean); 1:use real-time river temperature observations
River_Basin_Name: Name of Rivers or river basins
River_Station_Name: Name of Rivers or stations

(c)

Figure A.2 River control file for DBOFS, Section 1 (a), Section 2 (b) and Parameter Definitions (c)

Section 1: Information about USGS rivers where real-time discharges are available

51 26 1.0 !! NIJ NRIVERS : number of model locations (NIJ) and number of USGS river stations (NRIVERS)

RiverID	USGS_ID	NWS_ID	Q_min	Q_max	Q_mean	T_min	T_max	T_mean	Q_Flag	TS_Flag	River_Station_Name
1	01487000	XXXXX	0.18	85.47	2.64	0.80	27.90	15.06	1	1	Nanticoke River near Bridgeville, DE
2	01491000	XXXXX	0.01	197.25	3.85	-999.0	-999.0	-999.0	1	0	Choptank River near Greensboro, MD
3	01491500	XXXXX	0.04	95.94	2.74	0.00	29.20	13.65	1	0	Choptank River near Ruthsburg, MD
4	01495000	XXXXX	0.06	299.98	1.98	-999.0	-999.0	-999.0	1	0	Big Elk Creek at Elk Mills, MD
5	01578310	CNWM2	4.08	31979.00	1161.15	-999.0	-999.0	-999.0	1	0	Susquehanna River at Conowingo, MD
6	01580520	XXXXX	1.25	328.28	7.05	-999.0	-999.0	-999.0	1	0	Deer Creek near Darlington, MD
7	01581757	XXXXX	0.20	254.13	2.59	-999.0	-999.0	-999.0	1	0	Otter Point Creek near Edgewood, MD
8	01589352	XXXXX	0.18	676.37	2.55	-999.0	-999.0	-999.0	1	0	Gwynns Falls at Washington Blvd., MD
9	01646500	BRKM2	1.87	13697.20	323.19	-0.30	34.00	15.55	1	1	Potomac River near Washington, DC
10	01658000	XXXXX	0.00	263.19	1.62	-0.10	29.10	13.55	1	1	Mattawoman Creek near Pomonkey, MD
11	01594440	XXXXX	0.91	880.13	10.81	-999.0	-999.0	-999.0	1	0	Patuxent River near Bowie, MD
12	01594526	XXXXX	0.01	919.75	2.89	-999.0	-999.0	-999.0	1	0	Western Branch at Upper Marlboro, MD
13	01668000	FDBV2	0.14	3962.00	47.37	-0.10	34.40	15.71	1	1	Rappahannock River near Fredericksburg, VA
14	01673000	XXXXX	0.57	846.17	29.83	-0.10	32.20	15.45	1	0	Pamunkey River near Hanover, VA
15	01674500	XXXXX	0.01	478.27	16.10	0.00	30.00	15.00	1	0	Mattaponi River near Beulahville, VA
16	02037500	RMDV2	0.28	8857.90	193.43	-999.0	-999.0	-999.0	1	0	James River near Richmond, VA
17	02041650	MTCV2	0.48	1154.64	37.30	-999.0	-999.0	-999.0	1	0	Appomattox River at Matoaca, VA
18	02049500	FKNV2	0.00	650.90	18.03	-999.0	-999.0	-999.0	1	0	Blackwater River near Franklin, VA
19	02051500	XXXXX	0.06	1075.40	14.07	-0.20	29.90	15.20	0	1	Meherrin River near Lawrenceville, VA
20	02035000	XXXXX	8.94	10244.60	198.86	-0.50	36.00	15.77	0	1	James River at Cartersville, VA
21	01673638	XXXXX	0.00	40.47	0.20	0.10	34.00	15.77	0	1	Cohoke Mill Creek near Lester Manor, VA
22	01649500	XXXXX	0.04	339.60	2.48	-0.20	32.20	14.20	0	1	NE Branch Anacostia River at Riverdale, MD
23	01649190	XXXXX	-999.0	-999.0	-999.0	-0.20	25.50	10.91	0	1	Paint Branch near College Park, MD
24	01570500	XXXXX	45.28	28866.00	977.48	0.00	32.00	12.93	0	1	Susquehanna River at Harrisburg, PA
25	01481500	XXXXX	0.91	812.21	14.21	0.00	29.20	13.65	0	1	Brandywine Creek at Wilmington, DE
26	01490120	XXXXX	-999.0	-999.0	-999.0	-0.30	35.20	17.27	0	1	Little Blackwater River near Cambridge, MD

(a)

Section 2: information of ROMS grids to specify river discharges

GRID_ID	I/Xpos	J/Ypos	DIR	FLAG	RiverID_Q	Q_Scale	RiverID_TS	TS_Scale	River_Basin_Name
1	247	145	0	3	1	-0.448	1	1.000	Nanticoke River near Bridgeville, MD
2	247	146	0	3	1	-0.552	1	1.000	Nanticoke River near Bridgeville, MD
3	296	173	0	3	2	-0.317	26	1.000	Choptank River near Greensboro, MD
4	296	174	0	3	2	-0.339	26	1.000	Choptank River near Greensboro, MD
5	296	175	0	3	2	-0.348	26	1.000	Choptank River near Greensboro, MD
6	296	176	0	3	2	-0.348	26	1.000	Choptank River near Greensboro, MD
7	296	177	0	3	2	-0.390	26	1.000	Choptank River near Greensboro, MD
8	177	290	1	3	4	-0.103	25	1.000	Big Elk Creek at Elk Mills, MD
9	178	290	1	3	4	-0.102	25	1.000	Big Elk Creek at Elk Mills, MD
10	179	290	1	3	4	-0.102	25	1.000	Big Elk Creek at Elk Mills, MD
11	180	290	1	3	4	-0.101	25	1.000	Big Elk Creek at Elk Mills, MD
12	181	290	1	3	4	-0.100	25	1.000	Big Elk Creek at Elk Mills, MD
13	182	290	1	3	4	-0.100	25	1.000	Big Elk Creek at Elk Mills, MD
14	183	290	1	3	4	-0.100	25	1.000	Big Elk Creek at Elk Mills, MD
15	184	290	1	3	4	-0.100	25	1.000	Big Elk Creek at Elk Mills, MD
16	185	290	1	3	4	-0.096	25	1.000	Big Elk Creek at Elk Mills, MD
17	186	290	1	3	4	-0.096	25	1.000	Big Elk Creek at Elk Mills, MD
18	145	255	0	3	5	0.198	24	1.000	Susquehanna River at Conowingo, MD
19	145	256	0	3	5	0.158	24	1.000	Susquehanna River at Conowingo, MD
20	145	257	0	3	5	0.138	24	1.000	Susquehanna River at Conowingo, MD
21	145	258	0	3	5	0.137	24	1.000	Susquehanna River at Conowingo, MD
22	145	259	0	3	5	0.165	24	1.000	Susquehanna River at Conowingo, MD
23	145	260	0	3	5	0.217	24	1.000	Susquehanna River at Conowingo, MD
24	156	239	1	3	7	-0.333	23	1.000	Otter Point Creek near Edgewood, MD
25	157	239	1	3	7	-0.333	23	1.000	Otter Point Creek near Edgewood, MD
26	158	239	1	3	7	-0.333	23	1.000	Otter Point Creek near Edgewood, MD
27	146	216	0	3	8	0.429	23	1.000	Gwynns Falls at Washington Blvd., MD
28	146	217	0	3	8	0.571	23	1.000	Gwynns Falls at Washington Blvd., MD
29	1	130	0	3	9	0.187	9	1.000	Potomac River near Washington DC
30	1	131	0	3	9	0.149	9	1.000	Potomac River near Washington DC
31	1	132	0	3	9	0.131	9	1.000	Potomac River near Washington DC
32	1	133	0	3	9	0.533	9	1.000	Potomac River near Washington DC
33	34	135	1	3	10	-1.000	10	1.000	Mattawoman Creek near Pomonkey, MD
34	58	156	0	3	11	0.372	22	1.000	Patuxent River near Bowie, MD
35	58	157	0	3	11	0.446	22	1.000	Patuxent River near Bowie, MD
36	58	158	0	3	11	0.439	22	1.000	Patuxent River near Bowie, MD
37	60	102	0	3	13	0.374	13	1.000	Rappahannock River near Fredericksburg, VA
38	60	103	0	3	13	0.626	13	1.000	Rappahannock River near Fredericksburg, VA
39	80	68	0	3	14	0.139	21	1.000	Pamunkey River near Hanover, VA
40	80	69	0	3	14	0.262	21	1.000	Pamunkey River near Hanover, VA
41	80	70	0	3	14	0.459	21	1.000	Pamunkey River near Hanover, VA
42	80	71	0	3	14	0.402	21	1.000	Pamunkey River near Hanover, VA
43	80	72	0	3	14	0.266	21	1.000	Pamunkey River near Hanover, VA
44	20	49	0	3	16	0.222	20	1.000	James River near Richmond, VA
45	20	50	0	3	16	0.294	20	1.000	James River near Richmond, VA
46	20	51	0	3	16	0.259	20	1.000	James River near Richmond, VA
47	20	52	0	3	16	0.201	20	1.000	James River near Richmond, VA
48	20	53	0	3	16	0.124	20	1.000	James River near Richmond, VA
49	20	54	0	3	16	0.094	20	1.000	James River near Richmond, VA
50	142	45	1	3	18	0.474	19	1.000	Blackwater River near Franklin, VA
51	143	45	1	3	18	0.526	19	1.000	Blackwater River near Franklin, VA

(b)

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PARAMETER DEFINITION:

NIJ      :  Number of model grids to specify river discharges
NRIVERS  :  Number of USGS river observing stations
DELT     :  Time interval in hours for output time series
RiverID  :  Serial Identification number of USGS River
USGS_ID  :  USGS river Identification number
NWS_ID   :  NWS Identification number for USGS river
GRID_ID  :  Serial Identification number for Model grid location to specify river input
I/Xpos   :  XI-position of model grid at RHO-points
J/Ypos   :  ETA-position of model grid at RHO-points
DIR      :  River runoff direction. 0:along x/xi-axis; 1:along y/eta-axis
FLAG     :  River runoff trace flag. 0: all tracers (T & S) are off; 1: only T is on; 2: only S is on; 3: both T and S are on
RiverID_Q:  RiverID in Section 1 which is used to specify river discharge at the corresponding model grid
RiverID_T:  RiverID in Section 1 which is used to specify river temperature at the corresponding model grid
Q_Scale  :  Scaling factor of river discharge at the model grid
T_Scale  :  Scaling factor of river tempature at corresponding model grid
Q_min    :  Minimum discharge value of the river
Q_mean   :  Average discharge value of the river
Q_max    :  Maximum discharge value of the river
T_min    :  Minimum temperature value of the river
T_mean   :  Average temperature value of the river
T_max    :  Maximum temperature value of the river
Q_Flag   :  0:use climatological river discharges data(daily mean); 1:use real-time river discharge observations
T_Flag   :  0:use climatological temperature data(daily mean); 1:use real-time river temperature observations
River_Basin_Name:  Name of Rivers or river basins
River_Station_Name:  Name of Rivers or stations
```

(c)

Figure A.3 River control file for CBOFS, Section 1 (a), Section 2 (b) and Parameter Definitions (c).